5. Discussion

When doing surgery in athletic horse, the optimal objective is returning it to athletic soundness. A return to athletic soundness can only occur if the joint is not too seriously damaged by the original injury or by the surgeon. The decision to invade the joint surgically, involve the selection of the surgical technique to be used. Currently, surgical techniques for joint problems have gone through considerable sophistication and the two greatest advances in equine orthopedic surgery are internal fixation of fractures and arthroscopic surgery (McIlwraith and Bramlage, 1996). In our opinion, there are another two fast developing technology in the human orthopedic during the last few years, integrating fluoroscopic bone and joint surgery and image guided surgery (computer assisted surgery). In the present study, we try to enhance the fluoroscopic guided surgical technique as a minimal invasive method to allow support of the entire surgical procedures within the different equine joints.

5.1. Fluoroscopic imaging

Fluoroscopic joint guided surgery has not been commonly practiced in equine orthopedic surgery because the majority of surgeons and practitioners lack the experience and equipments and there is a concern among orthopedic surgeons about increasing level of exposure to radiation associated with intraoperative C-arm fluoroscopy (Levin, et al. 1987; Boening, 2002; Keegan and Dyson, 2003) although fluoroscopic guided surgery have been utilized extensively for orthopedic surgery in man.

Over the past 4 years, our clinical experience with the C-arm device has led us to several observations and recommendations regarding the optimum use of this device. We have found that the bony and soft tissue anatomy in the limb region to be particularly amenable to the C-arm device. The C-arm diameter is especially convenient for limb positioning and manipulation within the X-ray beam. The C-arm can be rotated 90º in many planes which enables us to see the operating field in different projections. Other advantages of this imaging system include easy mobility and a capability for image documentation on thermal paper. A significant advantage to this device is that there is no need for trained and expensive radiology personnel and a lead lined room is not necessary. The main indication for the C-arm technique in bone and joint surgery results from the pathological finding of radiological presentation (Hertsch and Höppner, 2000). Primary indication is the extirpation of radiological isolated shadows within the joints or in the surrounding tissue. Further possibilities for application of the C-arm technique are surgical repair of intra-articular fractures, surgical therapy for subchondral cystic lesions with cancellous bone grafting after drilling the cyst, and surgical arthrodesis of the joints. Other specific applications in our clinic include foreign body localization, angiography, and teeth surgery.

The results of the present data prove that fluoroscopic guided joint surgery is an effective and appropriate means of treatment of joint injuries. The advantages of this technique include minimal disruption of soft tissues and blood supply, decreased risk of infection, accuracy and earlier return to function. The disadvantages attributable to the use of intraoperative fluoroscopy include the exposure to ionizing radiation and the cost of the equipment.

5.2. Radiation exposure

Orthopedic surgeons are major user of fluoroscopic imaging, but they are sometimes unaware of the risk of occupational exposure radiation. Currently, there is little published information regarding the occupational risk to veterinary orthopedic surgeons who uses ionizing radiation. Detrimental health effects of ionizing radiation are classified as deterministic (nonstochastic) or stochastic. Deterministic effects results from killing of cells, which, if radiation dose is large, cause sufficient cell loss to impair tissue or organ function. Stochastic effects, unlike deterministic effects, do not have a defined threshold above which damage become evident. They result when an irradiated cell is modified but not killed (Mettler and Upton, 1995).

To avoid the fore mentioned deterministic effects, the natural council of radiation protection and measurement recommends an annual maximum permissible dose (MPD) for 500 mSv for the extremities (NRPB 1990). Nölker and Ueltschi (2001) designed a study to determine the exposure of personnel towards X-ray irradiation during veterinary radiographic examination with the C-arm X-ray unit and it was estimated that the legal limit of 500 mSv/ year will be exceeded when exposed to X-rays for about 16 hours per month provided that protection is used. In our study we have evaluated radiation exposure to the hands of the surgeons and assistant surgeons during all fluoroscopic guided procedures that were performed in one year and we found that the doses received were within the acceptable limits and did not approach the annual MPD. This similar with the study of Goldstone, et al. (1993); Lo, et al. (1996); O’ Rourke, et al. (1996) and Sutherland and Finlayson (1998), who evaluated radiation exposure to the hands of orthopaedic surgeons during fluoroscopic guided procedures and found that, even the surgeons performing the greatest number of operations did not approach the annual MPD.

In another study, Thomas, et al. (1999) determined radiation exposure to the hands of personnel during fluoroscopic imaging of horses limbs with a portable unit. They found that fluoroscopic imaging of limbs of horses represents a major source of radiation exposure. Annual exposure for fluoroscopists was more than twice the recommended MPD. In our opinion, unlike the routine joint examination, in which fluoroscopy is usually used for long time, fluoroscopic guided surgery require fluoroscopy for short bursts. The use of the shortest possible fluoroscopy time appreciably reduces the total radiation dose since the radiation load increases in proportion to the fluoroscopy time.

The C-arm devices operate in either strobe or real time modes. A further reduction of exposure level is possible if a strobe mode is used. When operated in the strobe mode, the X-ray tube is transiently energized for 2 seconds or less to form an image which retained on the screen for diagnosis and review. A new automode feature added to the C-arm device which incorporates the real time and strobe modes into one function controlled by the foot pedal. The power and kV are automatically set according to the density of the material being used, and the lowest are given for the optimal imaging. The exposure to the patient and medical personnel in the area is reduced by virtue of the short ´´beam on`` time necessary to obtain a suitable image.

When fluoroscopy is employed in the extremity surgical procedures, the limb is often fixed on a special stand and then the C-arm unit is brought into the operative field in an upright position with the X-ray tube below. Tremains, et al. (2001) found that the use of the inverted C-arm technique with the image intensifier as an operating table can significantly reduce radiation exposure to the surgeon and the patient during surgical procedures on human upper extremities. On the other hand, we find that the use of the image intensifier as a table is not practical for equine limbs. In addition, Goldstone, et al. (1993) stated that, keeping the image intensifier as close to the patient as possible minimizes the overall distance between the focal spot and image receptor. This geometry keeps the fluoroscopic beam intensity as low as possible, allows the image intensifier to serve as a scatter barrier between the patient and operator, and minimizes image blur simultaneously.

In the present study, it was showed that those working a way from the C-arm as the anesthetists receive no radiation. This similar to the finding of Tasbas, et al. (2003), who found that those working 90 cm away from the beam receive an extremely low amount of radiation and those working 150 cm a way receive nearly nothing. Therefore, the anesthetists are not at risk of cumulative ionizing radiation.

In our work we are in agreement with Miller, et al. (1983) and Tasbas, et al. (2003), who reported that the usage of lead aprons reduces the radiation dosages to negligible levels even when working near the X-ray source. The main disadvantages of wearing lead apron are excessive sweating and restricted motion due to its weight. Nevertheless, it has an important effect on reducing the exposed dosage of ionizing radiation.

Fluoroscopic guided surgery clearly represents a substantial radiation safety hazard that must not be ignored. Because it is impossible to determine a safe amount of exposure to ionizing radiation, all reasonable precautions should be taken to minimize exposure of involved personnel. Such precautions are particularly important in preventing stochastic effects, which do not have known dose thresholds. Radiation exposure can be reduced by a combination of the following methods: increasing distance from the primary beam, reducing the time of exposure, using of barrier, using the smallest possible fluoroscopic field, using the fully automatic fluoroscopic mode, and using film badges for personnel monitoring.

On the basis of results of the study reported here, it can be concluded that personnel are exposed to a little amount scatter radiation during fluoroscopic guided surgical procedures provided that all reasonable precautions are applied.

5.3. Fluoroscopic guided extirpation of isolated shadows from the region of the extensor process of the third phalanx.

Several techniques and methods for treatment of isolated shadows involving the extensor process of the third phalanx were studied. Pettersson (1976) found that conservative treatment consisting of blistering, firing, and rest for 3 to 10 months was successful in 8 of 22 cases. In addition Brems, et al. (1986) reported that small acute extensor process fractures may be successfully treated with fibrin adhesive. Arthrotomy was used successfully for surgical extirpation of both small and large fragments (Duncan and Dingwall, 1971; Scott, et al. 1979 and Dechant, et al. 2000). On the other hand, Boening, et al. (1989) and McIlwraith (1990a), preferred the arthroscopy technique over arthrotomy for removal of small fragments because this technique reduces tissue damage, improve cosmoses, permits a thorough evaluation of the joint, and minimizes recovery time.

Limited information exists regarding the use of fluoroscopic guided surgical technique for extirpation of isolated shadows involving the extensor process of the third phalanx and only Hertsch (1992) reported the first use of this technique successfully. In the present study we try to describe and establish this technique as a simple minimally invasive technique to overcome the disadvantages associated with use of arthrotomy or arthroscopy techniques.

Boening (2002) mentiond that, the most obvious disadvantages of treatment via arthrotomy are the significant risk of postoperative DJD, osteophytes and new bone formation, and damage and secondary malformation of the dorsal hoof wall combined with loss of hoof wall stability. Whereas, Boening, et al. (1989) found that the most obvious disadvantages of treatment via arthroscopy is the difficulty to work with arthroscope in this small joint, the orientation of the instruments within the hoof joint is difficult and sophisticated, the need of 2 incisions one for the arthroscope and one portal for the instrument, and long operation time. In addition, we fell that arthoscopy would not result in better visual evaluation and access to large fragments and those ones which are embedded within the CDET or joint capsule or obscured by hypertrophied synovial villi.

In the present study surgical removal of isolated shadows in the region of the extensor process of the third phalanx was chosen to eliminate the source of irritation from the joint and to avoid the development of advanced DJD. Moreover removal of the isolated shadows can stimulate the synovial membrane to produce synovial fluid of a good quality. An additional benefit to surgery is a shortened convalescent period. On the same line Humans and Winzer (1961); Duncan and Dingwall (1971); Haynes and Adams (1974) and McIlwraith (1990a) indicated also the use of surgery for the same reasons.

Regarding the radiographical diagnosis of isolated shadows proximal to the extensor process of the third phalanx, they were best visualized on lateromedial radiographic projections, at the same time, oblique projections were taken to aid in assessment of arthritic changes within the joint. The X-ray finding of isolated shadows proximal to extensor process of the third phalanx, usually do not allowed the clinician the possibility to make an exact and definite diagnosis. These may be separate centers of ossification (osteochondrosis lesions), ectopic calcification (metaplasia) within the CDET or the joint capsule, or fracture of a marginal osteophytes and consequently radiographic differentiation may not possible. Only differential patho-anatomical, clinical, and etiological investigation must be performed before the exact diagnosis.

In our results, 9 cases revealed incomplete removal of the isolated shadows at the post operative control X-ray. This rest fragments were not clear in final fluoroscopy image in 3 cases. For this reason an intraoperative control X-ray may be very important.

Results from the present study we are in agreement with those of Pettersson (1976); Scott, et al. (1979); Harfst (1986); Yovich (1989); Honnas, et al. (1992) and Berton (1996), who mentioned that extensor process isolated shadows, were predominantly found in the forelimbs and were not detected in the hindlimbs of horses in our study.

We are also in agreement with Terberger (1988) in that isolated shadows of the extensor process of the third phalanx are more common in older horses, compared with younger horses. On the other hand we are not in agreement with Dechant, et al (2000), who reported that large fragments of the extensor process are more common in younger horses.

Results of the study reported here do not support the hypothesis of a breed predisposition for development of isolated shadows of the extensor process of the third phalanx; proportions of the breed in our study were similar to those of general hospital population at the equine clinic Free University of Berlin. This finding is consistent with the findings of Pettersson (1976) and Dechant, et al. (2000).

Male horses were overrepresented in our study group, compared with female horses. This finding is also consistent with findings of Pettersson (1976); Scott, et al. (1979) and Dechant, et al. (2000). This apparent sex predisposition may be related to a willingness to pursue treatment in non breeding animals.

The present study found that gelding had a higher incidence than stallions and mares were moderately affected. Hormonal disturbances in geldings may play a role, but this factor needs further study.

In the present study, as the incision must be directly over the dorsum of the extensor process which located exactly in the mid line. We have found that, it is convenient to mark the exact midline prior to surgery, in as much as surgical draping may obscure this point.

Initial concern for disruption of a large portion of the CDET was alleviated by excellent post surgical progress. Similar findings were described by Scott, et al. (1979), who mentioned that CDET insertion is expansive, and fibroplasia at the surgical site apparently resulted in regrowth and reattachment of the divided portion of this tendon from its original insertion site. A 4- to 8-weeks stall confinement should allow sufficient time for healing.

Concerning the technique of fluoroscopic guided surgery, the result obtained from this work established that this technique was simpler, quicker, easier and more cosmetic minimal invasive technique in comparison with arthrotomy or arthroscopy technique. In contrast with arthrotomy the surgical incision is considerably smaller and only one incision is required in comparison with arthroscopy, which need 2 incisions. Moreover, the orientation and monitoring of the instruments within the joint was also very easy.

Although Boening (2002) mentioned that the use of fluoroscopic guidance for anatomic orientation is helpful during diagnostic arthroscopy of the palmar/plantar pouch of the coffin joint and under such visualization, insertion of the arthroscope, insertion of hand instruments, and identification of the fragment side can be achieved. At the same time the same author hypothesized that arthroscopy is the method of choice for removal of all sizes of fragments of the extensor process and arthrotomy, even under fluoroscopic guidance is no longer an appropriate option for fragment removal. Exposure and increased uptake of radiation by all people in the surgical theater and the lack of direct visualization of the fragment itself and the origin of the fragment are disadvantages for fragment removal via arthrotomy under fluoroscopic guidance. The results of our study are not in agreement with these hypotheses.

These hypotheses are also not in agreement with Dechant, et al. (2000), who mentioned that arthrotomy is the method of choice for removal of large sizes fragments of the extensor process, because arthroscopy would not result in better visual evaluation and access to large fragments.

An unsuccessful outcome developed in 4 horses with large isolated shadows after surgery. Horses with unsuccessful outcomes did not have larger fragments than horses with successful outcomes. 3 of the 4 horses had a history of very long duration lameness prior to surgery and also had evident of osteoarthritis before surgery. One horse developed osteoarthritis of the distal intrerphalangeal joint after surgery. In general we fell that the ability to achieve successful outcome may be enhanced by performing surgery at the earlist possible stage and by careful management of the convalescent period. Similar findings were reported by Boening, et al. (1989), who mentioned that these fragments are always pathological and should be removed as early as possible.

The present series support the use of fluoroscopic guided minimal invasive technique for removal isolated shadows in the region of the extensor process of the third phalanx as alternative to arthrotomy or arthroscopy. Clearly, appropriate radiological protection precautions must be taken and, in addition, the necessary equipment is expensive and not widely available, but the author and other clinicians at our clinic find the method to be rapid and effective in the majority of cases especially for retrieval of isolated shadows which buried within the CDET or reactive tissues. No complications specific to the C-arm technique were encountered in this study other than its failure to remove the isolated shadows in certain cases.

5.4. Fluoroscopy guided internal fixation of fractured extensor process of third phalanx

Pettersson (1976); Rose, et al. (1979); Yovich, et al. (1982); Honnas, et al. (1992) and MacLellan, et al. (1997) described the lag screw fixation of extensor process fractures in horses via the use of arthrotomy technique. In the present investigation, a fluoroscopic guided technique was used successfully for application of lag screw fixation and this technique was feasible and easy to perform. The advantages of fluoroscopic guided surgery technique over arthrotomy technique include shorter operation time, less incisional exposure (more cosmetic wound appearance), enhanced visibility (monitoring) of the screw insertion and the fracture line compression, and a shortened convalescent period.

Regarding the type of screw which used for fixation of the fractured extensor process, a self tapping (malleolar) screw was used rather than a cortical bone screw because it has a smaller head and allows compression without oversize drilling of the fracture fragment. The malleolar screw was not removed in this case. Haynes and Adams (1974) mentioned that, any attempt to remove this screw would likely have resulted in a broken screw because osseous tissue deposited around the unthreaded shaft of the screw would have restricted withdrawal of the threaded portion.

5.5. Fluoroscopic guided extirpation of isolated shadows from the dorsal aspect of the proximal interphalangeal joint.

In our work only 3 cases subjected to successful removal of isolated shadows from the dorsal aspect of PIP joint. This few number of operated cases could be attributed to, the low frequency of occurrence of this condition within the PIP joint, as Mondransky, et al. (1982) and Stashak (1987), who mentioned that osteochondral chip fractures of the PIP joint are considered rare.

Results from the present study are in agreement with thops of Colahan, et al. (1981) and Stashak (1987), who reported that the pelvic limb is affected three times more frequently than the thoracic limb.

Depending on the horse's intended purpose, amount of articular surface involved, duration, or degree of lameness present, isolated shadows of the PIP joint may be treated conservatively (Stashak, 1987), or surgically removed via arthrotomy (Modransky, et al. 1982 and Torre, 1997) or arthroscopy (Schneider, et al. 1994 and Nixon, 1990). On the other hand there is no information in the literatures regarding fluoroscopic guided surgical removal of isolated shadows of the PIP joint. In the present study, we try to introduce this technique as a new simple technique to overcome the problems and difficulties associated with the other surgical techniques.

The cause of the isolated shadows in the PIP joints in the horses of this study was not determined. They could have resulted from osteochondrosis and failure of typical endochondral ossification. The age of horses, the unilateral joint involvement, and the evidence of no lesions typical of osteochondrosis in other joints would not support this theory.

Trotter, et al. (1982) reported that isolated shadows localized to the PIP joint is usually associated with a wide spread cartilage damage and severe DJD. Other pathologic lesions were not observed in these joints, and the 3 horses were not lame after surgery. It is possible that these fragments were bone fractures that resulted from trauma to the dorsoproximal margin of the middle phalanx, but this was unlikely because of the limited motion in the PIP joint.

In this study it was observed that horses with abnormal enlargement or swelling of the PI joint may have isolated shadows of this joint. Similar finding was described by Schneider, et al. (1994).

Also we have observed that positioning the limb in maximal extension and distending the joint with sterile Ringer solution facilitate placement and maneuver of the instruments into the joint space.

After our study we can conclude that fluoroscopic guided surgery is a useful and easy technique for removal of isolated shadows of the dorsal aspect of PIP joint. A better localization of the lesions was obtained by use of the fluoroscope than is possible by use of arthroscope or arthrotomy in the same location. This is in agree with Schneider, et al. (1994), who stated that the small joint capsule, and the tension on the extensor tendon and joint capsule, limit the exposure obtained by retraction of an arthrotomy incision. Also the limited space in the dorsal joint pouch makes accurate location of the arthroscopic portal critical and placement of the portal too far proximally limits the ability to view the joint space.

5.6. Fluoroscopic guided extirpation of isolated shadows from the fetlock joint.

Before the advent of minimal invasive surgery, surgical removal of isolated shadows from the fetlock joint was not routine, because some surgeons questioned the benefits after surgical invasions of this area with arthrotomy (Raker, 1973 and Meagher, 1974). In our opinion, however, a horse with problems related to the fetlock joint and radiographically evident isolated shadows within the fetlock joint is a good candidate for surgery and this is agree with McIlwraith (1990a), who mentioned that minimal invasive joint surgery via arthroscopy can provide a faster return to function and help to minimize the degenerative changes that could possibly develop.

Meagher (1974); Ferraro (1978); Haynes (1980) and Raker (1975) reported several complications associated with fetlock arthrotomy including decreased range of joint motion secondary to fibrosis at the surgical site, joint capsule thickening, adhesions of the joint capsule close to the articular edge of the P1, considerable periarticular bone growth, and calcification of the joint capsule and synovial membrane at the surgical site. In this series, no one of the previous complications was observed after fluoroscopic surgery. This may be attributed to the minimal invasive technique in which a small area of joint capsule penetrated through a small stab incision and the fact the area of the joint capsule attachment to bone is undisturbed by this procedure, except when the isolated shadow is attached at this site. Another important advantage that has been observed for fluoroscopic guided surgery over arthrotomy is the decreased convalescence period; hence minimal soft tissue trauma is caused by fluoroscopy, compared with an arthrotomy incision.

Because of complications associated with fetlock arthrotomy, the above mentioned authors recommended conservative management of 4-6 months and no corticosteroid administrated intra-articularly. It is said that most fractures will heal with time; although this is probably true, no follow-up study after this conservative regimen has been reported, only several horses in one study were rested for 3 or more months without resolution of lameness until arthroscopic removal was performed (Yovich and McIlwraith 1986). In our work we recommended the surgical removal and this agree with Ellis and Reyonalds (2001) who mentioned that loose osteochondral fragments and other articular debris released from the fracture site produce mechanical trauma which may result in significant secondary joint lesions. In addition inflammatory mediators produced by, or in response to fragmentation are potent contributors to self perpetuating circles of DJD. There fore early removal of detected isolated shadows is usually mandatory for anticipated or continued athletic function.

In our study a positive response to fetlock flexion test was found to be a good indicator for the presence of fetlock lesion. This is in agreement with Birkland (1972); Pettersson and Ryden (1982); Houttu (1991) and Whitton and Kannegieter (1994). However, in contrast to this, Foerner, et al. (1987); Barclay, et al. (1987) and Nixon (1990) found fetlock flexion tests to be of little value. The presence of effusion is rarely, being recorded in few cases described here. Only one report (Pettersson and Ryden, 1982) found effusion in most cases, while Ross, et al. (1991); Houttu (1991) and Foerner, et al. (1987) rarely observed effusion.

The result of our work showed that 27 horses were subjected to surgical removal of isolated shadows from the dorsal proximal aspect of P1 (22 Warmbloods, 2 Thoroughbreds, 2 Standardbreds, and 1 Pony). This finding is inconsistent with finding of Yovich and McIlwraith (1986); Kawcak and McIlwraith (1994) and Berton (2002), who suggested that race horses, especially Thoroughbreds, may be predisposed to proximodorsal P1 fragmentation and this occurs during extreme fetlock extension at fast training or racing.

Birkland (1972); Barclay, et al. (1987); Foerner, et al. (1987); Nixon (1990); Grondahl (1992) and Sandgreen, et al. (1993) found that osteochondral fragments of the plantar eminence of P1 are common in Standardbred horses. Results of the study reported here showed that, this condition can also occur in other breeds.

The predilection of these fragments for the hindlimbs and the medial side of the joint is in agreement with the work of Foerner, et al. (1987); Pettersson and Ryden (1982) and Sandgreen (1988).

Barclay, et al. (1987) considered the medical treatment as a useful method for treatment of isolated shadows of the plantar aspect of the P1, but resulted in decrease in the horse's performance. On another hand, Foerner, et al. (1987) advocated the arthroscopic removal. In this study, surgical removal resulted in a good prognosis for return to previous intended use.

In the present study, we agree with Superlock and Gabel (1983); Parente, et al. (1993); Bertone (1996) and Sowthwood and McIlwraith (2000), who mentioned that apical fractures involving less than one-third of the proximal sesamoid bone are best treated by surgical removal of the fragment. Surgical treatment is preferred to reduce the risk of development of secondary DJD within the fetlock joint.

Also the results of the current study are in agreement with the work of Bukowiecki, et al. (1985) in that surgical removal of the fractures of the palmar/plantar wing of P1 is aimed at removing the cause of irritation to the joint. Occasionally, the fracture fragment is large, and surgical removal may cause a joint surface defect or possible joint instability. In that instance, surgical reduction and lag screw fixation is preferable.

The result of this study also show that the number of operated fetlock joints, isolated shadow location or specific limb affected have little influence on the prognosis for return to the previous use. This is in agreement with the study of Kawcak and McIlwraith (1994).

Hertsch and Höppner (2000) mentioned that, the isolated shadows within the joint or the joint vicinity can appear in different locations:

1. Free joint bodies (corpora libera) within the joint cavity in either the region of the articular surface or the joint capsule.
2. Osteochondral fragments associated with osteochndrosis dissecans, usually found in connection with the articular surface.
3. Traumatic intra-articular avulsion fractures with different fragment dislocations.
4. Metaplastic peri-articular pathological ossification of the joint capsule, ligament, or tendon (ectopic or dystrophic mineralization).
5. Peri-articular newly bone growths (osteophytes), usually found at the articular margin.

Our work showed that the fluoroscopic guided surgery is the most valuable technique for removal of the isolated shadows from the all different locations mentioned above, especially 4 and 5 locations which can not be detected arthroscopically.

For the he x-ray finding 'radiopaque opacity' within or in the vicinity of the equine joint many synonyms, all of them describe only the finding without any consideration to the exact aetiology and pathogenesis. The presence of these finding in an x-ray film, usually do not allowed the clinician the possibility to make an exact and definite diagnosis. Only differential patho-anatomical, clinical, and etiological investigations must be performed before the exact diagnosis. Fractures of the articular margin are termed chip fractures (Butler,et al. 1993). Differentiation between chip fractures, ectopic mineralization, and separate centers of ossification may not possible, therefore in our work we preferred the use of the term 'isolated shadow' for all radiopaque opacities within or in the vicinity of the joint.

In our work, the lateral recumbency was selected for all surgeries, because it was easier to switch the C-arm geometry in different projections to obtain the best localization of the lesions. Also we have found that for removal of isolated shadows from the dorsal aspect of the fetlock joint and the region of the extensor process of the third phalanx it is preferable to extend the foot with a clean rope which is fixed at the operating table edge. By extending the foot, it is easy to access the dorsoproximal aspect of P1 and the extensor process.

In the present work, we have observed that fluoroscopic guided surgery is probably the best example of what can be achieved with joint distension. Joint distension facilitates the recognition of the correct place for the instrument portal and minimizes the risk of iatrogenic trauma to the joint on entry of the instrument. Physiologic balanced polyionic solution should be used as an irrigating and distension medium. Normal saline and phosphate buffered saline negatively influence chondrocyte synthetic activity in vitro when compared to lactated Ringer's solution (Reagan, et al. 1983)

Contrary to some beliefs; the size of the fragment that can be removed has no limit. Fragments of all sizes can be removed through the initial incision hole in the joint capsule. Only the skin incision can be enlarged to accommodate the fragment size in some instances but additional incising the joint capsule is not usually required. Failure to lengthen the skin incision can often result in the isolated shadow being lost or trapped in the subcutaneous plane. Also the use of appropriate size forceps that can minimizes the risk of leaving fragments in the joint.

In the present study we advised no specific recommendation regarding intra-articular medication after surgery unless signs of DJD were detected either in the x-ray or arthroscopically, as the most important to the patient is removing the isolated shadow. The same advisement was stated by McIlwraith (1990a)

In our study we have observed that radiographs obtained postoperatively that confirm isolated shadows removal are most useful part of the record for cases in which problems (recalcification, refragmentation) develop later and the client claims that the isolated shadow was not removed.

Postoperative administration of antibiotics and anti- inflammatory drugs is controversial issues. There are diverging opinions regarding the indications, safety and justification of these drugs. We recommended no pre or postoperative antibiotics unless the body temperature is elevated. Also we prefer no postoperative anti-inflammatory drugs to give a chance to detect any disturbance in the limb function postoperatively.

In conclusion we found that fluoroscopic guided surgery is the most efficient minimal invasive technique in the fetlock joint, with its greatest usage being in both the dorsal and palmar/plantar aspects of the joint. In our study we find that the fluoroscopic guided technique is technically easier, quicker and more cosmetic than the arthroscopic technique and we serve arthroscopy for cases in which suspicion of DJD exist as we know that arthroscopy is powerful diagnostic and therapeutic tool. However, based on the results of our study we recommended the use of combination of both techniques for fetlock surgery.

5.7. Fluoroscopic guided surgical management of noncomminuted articular fractures of the proximal phalanx.

Results of the study reported here do not support the hypothesis of a breed predisposition for development of fractures of P1; proportions of breed in our study were similar to those of the general hospital population at the equine clinic, Free University of Berlin. Warmbloods were overrepresented. This finding is inconsistent with findings of Markel and Richardson (1985); Ellis, et al. (1987); Holcombe, et al. (1992) and Tetens, et al. (1997), who reported the development of these fractures only in racing Thoroughbred and Standardbred horses.

In this study, we observed that diagnosis of the fissure or incomplete mid-sagittal fractures of P1 can be difficult in the early stages, but with time and careful radiographic examination, the nature and extent of fracture can usually be demonstrated and attention to fracture configuration is essential before attempting to perform surgery.

Incomplete fractures of P1 can be managed conservatively with stall rest and bandaging or surgically with lag-screw fixation. Although Markel and Richardson (1985) and Ellis, et al (1987) found that there does not appear to be any difference in regard to percentage of horses that return to racing, between horses treated conservatively and horses treated surgically, in our study we adopted surgery to optimize the conditions for fracture healing by reduction the articular defect and placing the fracture under interfragmentary compression, which may minimize degenerative changes in the joint and to decrease the risk of fracture propagation.

To our knowledge, another study of horses with fractures of p1 that includes the use fluoroscopic guided surgery does not exist. In this study we attempt to introduce fluoroscopic guided surgery as a quickly minimal invasive method for treatment of intra-articular fractures. Without fluoroscopy guided technique, intra-operative monitoring of the drilling procedure with radiograph is necessary to check for screw placement and depth of the gliding hole (Gable and bukowiecki, 1983; Turner, 1982). The use of radiography require redraping and there a chance to break the septic surgical technique. Moreover there is a time-wasting that prolong the anaesthetic time.

The result of treatment of 19 cases of noncomminuted articular fractures of p1 indicate that fixation of these fractures using fluoroscopic guided lag-screw technique carry an obvious advantages over the traditional radiographic control during the operation, and as more experience is gained in their use, the number of success and accuracy should increase and the operation time should decrease.

Objectively evaluating the effect of any surgical procedures on horse's athletic performance is difficult. Many factors other than the original injury can affect whether a horse returns to athletic performance. In the present study, horses with noncomminuted p1 fractures were found to have a good prognosis for return to athletic activity. On the same line Gable and Bukowiecki (1983); Ellis, et al. (1987); Barr, et al. (1988) and Holcombe, et al. (1995) observed the same results.

In our work we recommended joint puncture after the completion of osteosynthesis and joint irrigation with sterile Ringer solution when haemarthrosis was encountered.

The quality of healing evaluated on 2-4 months follow-up radiography appears to be an important predictor of fracture performance. In our clinic, we do not customarily recommended screw removal unless lameness can be directly attributed to their presence; we believe that most horses can perform the intended use with screws in place. As the reaction around the screw head was minimal, it was decided not to remove the screws.

5.8. Fluoroscopic guided surgical management of condylar fractures of MC-3 or MT-3.

In the present investigation, all horses were Thorougbreds, compared with the hospital population, suggesting that they may be predisposed to condylar fractures of MC-3 or MT-3. Similar results were obtained by Bassage and Richardson (1998).

Condylar fractures of MC-3 or MT-3 are almost exclusively the result of strenuous exercise. They are believed to result from interruption in the normal synchronous rotation between the first phalanx and MC-3 or MT-3 near the end of the weight-bearing phase of the stride that causes abnormal or excessive stress on the condyles during high-speed exercise (Roony 1974; Meagher 1976; Turner 1977; Baker 1979). It was suggested by Bassage and Richardson (1998) that these stresses are lower in magnitude or occur less frequently in other breeds than in Thoroughbreds.

In our results, there was no female horses subjected to surgical treatment of condylar fractures, and this may reflect the economic decision to retire seriously injured fillies and mares immediately after injury rather than to pursue treatment at a secondary care center. In addition Richardson (1984) suggested that the lighter body weight of the females in the racing population may be involved in a lower prevalence, compared with males.

Many factors influence the decision for treatment especially the length and extent of fracture, degree of lameness and financial considerations. In a prior study (Rick, et al. 1983), 9 of 10 incomplete nondisplaced fractures with conservative treatment raced, whereas 9 of 11 with surgery raced. Foerner and McIlwraith (1990) stated that all incomplete fractures should be treated conservatively. Many factors influence the decision for treatment especially the length and extent of fracture, degree of lameness and financial considerations. In this study all fracture types undergoing fluoroscopic guided internal fixation. Use of lag-screw fixation increases the horse's comfort considerably and decreases the chance of fracture line propagation and further extension of the fracture. Also lag-screw compression across a simple articular fracture improves the quality of hyaline cartilage repair (Mitschell and Shepard 1980)

Previous reports have stated that complete fractures, especially when displaced, carry a poor surgical prognosis (Haynes 1980; Rick, et al. 1983; Foerner and McIlwraith 1990; Ellis 1994).

In contrary, the 2 horses with complete displaced fractures in our study were found to have a good prognosis for return to athletic activity.

McIlwraith and Bramlage (1996) stated that internal fixation of the fracture must be accompanied by anatomic reduction with minimal damage to the soft tissue if the horse is to have any chance at athletic activity. Control of reduction of displaced condylar fracture is normally done by direct visualization, as it is difficult to maneuver and manipulate the condyle under arthroscopic control. In our work considerable effort was expanded intra-operatively with displaced fractures to achieve exact anatomic alignment. We fell that fluoroscopic guided surgery influenced positively the improvement of the surgical technique. The improvement of surgical technique over time has probably plays a role in improvement in return to athletic activity.

In our work we have observed that one screw may appear initially to be adequate for surgical repair, especially in case of incomplete condylar fractures. However, if the fractures become complete due to additional trauma during the recovery period or post-operative period, a single screw probably would be insufficient. Therefore we have used 2 screws. On the same line Rick, et al. (1983) advised the use of at least 2 screws for surgical repair of the incomplete or the complete- nondisplaced condylar fractures for the same reason.

In this series of horses, fluoroscopic guided lag-screw fixation was successful to bring accurate anatomic realignment of the articular surfaces and rigid interfragmantaly compression. In addition, from the technical point of view the fluoroscopic guided technique was simple, easy and quick to perform. Fluoroscopy has improved the surgical technique through proper alignment of the drill holes and accurate placement of ASIF cortical screws which is important to minimize the like hood of DJD.

5.9. Fluoroscopic guided surgical management of transverse, articular proximal sesamoid fracture.

In the present investigation, only one 6 years old Warmblood horse has subjected to fluoroscopic guided lag-screw fixation of transverse basilar fracture of the proximal sesamoid bone. This is inconsistent with Copelan and Bramlage (1983) and Henninger, et al. (1991), who reported these fractures, occur most commonly in young horses during training or racing as a result of excessive stress to the suspensory apparatus.

Transverse, articular sesamoid bone fractures are serious injuries that may severely limit future athletic endeavors. These fractures heal poorly because of inadequate periosteal or endosteal blood supply or both and because the fragments are distracted by continuous tensions generated by the suspensory apparatus (Buckowiecki, et al. 1985).

It has been stated that conservative management of transverse, articular sesamoid bone fractures carries a poor prognosis for return to function (Copelan and Bramlage, 1983; Medina, et al. 1980; Bukowiecki, et al. 1985). In this study, a good prognosis was obtained following fluoroscopic guided lag-screw fixation. Similar result was obtained by McKibbin and Armstrong (1970) and Fackelman (1978). Meantime Medina, et al. 1980 and Copelan and Bramlage (1983) had used bone grafting successfully for treatment of transverse, sesamoid bone fractures. Also Henninger, et al. (1991) recommended lag screw fixation combined with autogenous cancellous bone grafting for treatment of these fractures.

In the present case of proximal sesamoid bone transverse basilar fracture, the screw was placed in this manner to increase the holding power of the lag-screw by engaging a greater width of bone in the larger proximal fragment. For the same reason Henninger, et al. (1991) advised the placement of 4.5-mm screw from the base of the sesamoid bone in case of all large distal mid body fractures.

In conclusion, fluoroscopic guided surgery has rendered quicker and easier screw fixation of transverse basilar fractures of the equine proximal sesamoids. More accurate reduction of the fracture fragment, exact restitution of articular integrity, and appropriate orientation of the implant have led to greater surgical success as measured by more rapid healing and better post-operative performance.

5.10. Fluoroscopic guided surgical management of subchondral cystic lesions (SCLs) within the phalangeal joints.

Previous studies have confirmed a poor prognosis for soundness following conservative management of distal limb cysts (Pettersson and Sevelius, 1968; Kold and Hikman, 1990; Nixon, 1990). Meanwhile some locations such as the distal radius and the proximal and middle phalanges have been managed successfully with rest and anti-inflammatory therapy, albeit the number of cases reported was few (Pettersson and Reiland, 1969; Specht, et al. 1988; McIlwraith, 1990b). In the present study special attention has to be given to the clinical feature and the radiological findings of each case to decide whether to advice, conservative or surgical treatment. All cases severely lame, irrespective of the size of the cyst, should be undergoing surgery. All other cases should be treated conservatively with complete rest and the intra-articular injection of hyalauronic acid at 4 weeks intervals. If after 4 months rest, no improvement, then surgery is indicated. On the same line Kold (1990), Baxter (1996), and Kold and Killingbeck (1998) also suggested that horses with subchondral lesions not responding to conservative treatment within 3 or 4 months, or those that worsened should be treated surgically.

Kold and hickman (1983) found that the treatment of subchondral bone cysts in the medial femoral condyle by an autogenous cancellous bone graft results in the cystic cavity being replaced by normal bone in approximately 9 to 12 months, the opening of the cyst partially obliterated by fibrocartilage and normal functioning joint re-established. These results are in agreement with the result of the present investigation where no evidence of the presence of cyst was observed in some horses, eight months post-operatively.

In our work all the SCLs were diagnosed radiographically, at the same time the computer tomography has been valuable to confirm the diagnosis in case of SCL in the proximal sesamoid bone. At minimum, the diagnostic radiographic examination should include the dorsopalmar and standing lateromedial views to identify the cystic lesions in the region of the phalangeal joints, an elevated 45° dorsopalmar view provided optimal visualization of the borders of the cystic cavity in the condyles of Mc-3 and permitted assessment of radiographic communication of the lesion with the articular surface. Although the standard 30° oblique views did not consistently project the cystic lesion, these views were helpful in evaluating the joint for peri-articular changes associated with DJD, before and after surgical management. Similar observations were described by Hogan, et al. (1997).

In this study, a surgical technique was used whereby under fluoroscopic control an extra-articular opening was drilled into the cyst rather than approaching the cyst via the joint (arthrotomy). An intra-articular approach to the phalangeal joints would have required a more extensive surgical procedure due to poor accessibility of the central articular of the distal limb, low range of motion joints, and the limited space in the dorsal joint pouches. Also arthroscopic evacuation and debridement would have been impossible and would not have allowed installation of bone graft. Kold and Killingbeck (1998) described a similar technique for the treatment of SCLs in the distal phalanges of 3 cases, but the exact location and drill angle for drilling was established through using multiple intra-operative radiographs rather than using fluoroscopic monitoring.

In the present study, cancellous bone graft from the controlateral tuber coxae was harvested with a modified Jamshidi-needle. Alternative techniques for cancellous bone harvesting from the tuber coxae have been described (Stashak and Adams, 1975; Kold and Hickman, 1983; Kold and Killingbeck 1998). However, our technique is simpler, quicker, and more cosmetic. There is minimal soft tissue dissection, and the initial incision is generally smaller (2 cm) than those described for the other techniques. These results justify the use of the modified Jamshidi-needle for collection of cancellous bone graft in horses.

The Jamshidi-needle was described in the human literatures as a biopsy needle for bone and paranchymatous organs (Inwood, 1975; Wohlenberg, et al. 1978; Shaltot, et al. 1982; Glaccone, et al. 1987; Lewis, et al. 1988; Kraus, et al. 1996). In our work we have used a modified Jamshidi-needle (Hertsch, et al. 2000) which aid in harvesting of cancellous bone from the tuber coxae and further installation in subchondral bone cysts. This needle was chosen because of its simplicity, appropriate size, durability, and the inexpensive cost. This needle was designed to be appropriate with the osteosynthesis instruments. The needle has 4.2 mm outer diameter, which can pass through a 4.5 mm tap sleeve or the drill guide to reach the cyst cavity. The shaft of the needle is 50 mm long which is long enough to reach the cyst depth and in the same time short enough which cannot break up during the harvesting process. Other modifications which include, the presence of a fixed handle, metal stylet, and removable cover. These modifications allows for more precise use, prevention of instrument breakage, and greater convenience for the operator during harvesting and transplanting the bone graft.

Autogenous cancellous bone is the most commonly used type of bone graft in equine orthopedics; tuber coxae, medial side of the proximal tibia, sternum and the rib is the most frequently used donor sites (Stashak and Adams, 1975; Milne and Turner, 1979; Bramlage, 1981; Medina, et al.1980; Kold and Hickman, 1983; Richardson, et al. 1986). In the present work, tuber coxae has been used as a donor site because it is easy to access it when the horse is in lateral recumbency, the tuber coxae is non-weight bearing and there is no risk of pathological fracture following collection of cancellous bone, easy access to the tuber coxae as it not covered by muscle, and there is abundance of cancellous bone which can be collected. Moreover our results showed no postoperative complicatios as preincisional oedema or serum drainage.

Two surgical teams were used in this work. It is advisable to use a separate surgical team for harvesting the cancellous bone graft while surgery is being done to minimize the operating time. If surgery time is delayed, the graft will suffer unnecessary exposure, there fore decreasing the survival of graft cells (Stashak and Adams, 1975).

Howard, et al. (1995) and Hogan, et al. (1997) reported good clinical results without the use of bone graft instillation for treatment of SCLs in the medial femoral condyle and the condyles of MC-3 respectively. The cysts was only evacuated and concurrent osteostxis of the cyst cavity was performed in some cases, although cyst enlargement post-operatively and associated unsatisfactory outcome in some cases have been described. In our clinic at the present time we prefer the use of autogenous bone grafting technique based on clinical experience from large number of grafted cysts in other joints, especially the femoro-tibial joint. The use of bone grafting for treatment of SCLs resulted in, an immediate reduction in pain, elimination of the continuous and injurious action of synovial fluid, immediate access to a large portion of subchondral bone plate (Kold, 1990), and enhancement the early stages of healing of osseous tissues through the osteoconductive, osteoinductive, and osteoprotective potential of bone graft (Urist, 1980; Prolo and Rodrigo, 1985).